International Living with a Star ***COSPAR/IAC***

Perspectives of Russian participation in international LWS research and operational network

Space SEGMENT

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TOPICS:

- **CORONAS-F – mission in flight**
- **CORONAS-PHOTON - mission under development**
- **INTERHELIOPROBE – mission under investigation**
- **RESONANCE - mission under investigation**
- **INTERBALL-PROGNOZ – project under discussion**
- **ROY - project under discussion**
- **Real-time data and forecast**

- **CORONAS-F – mission in flight**

CORONAS-F

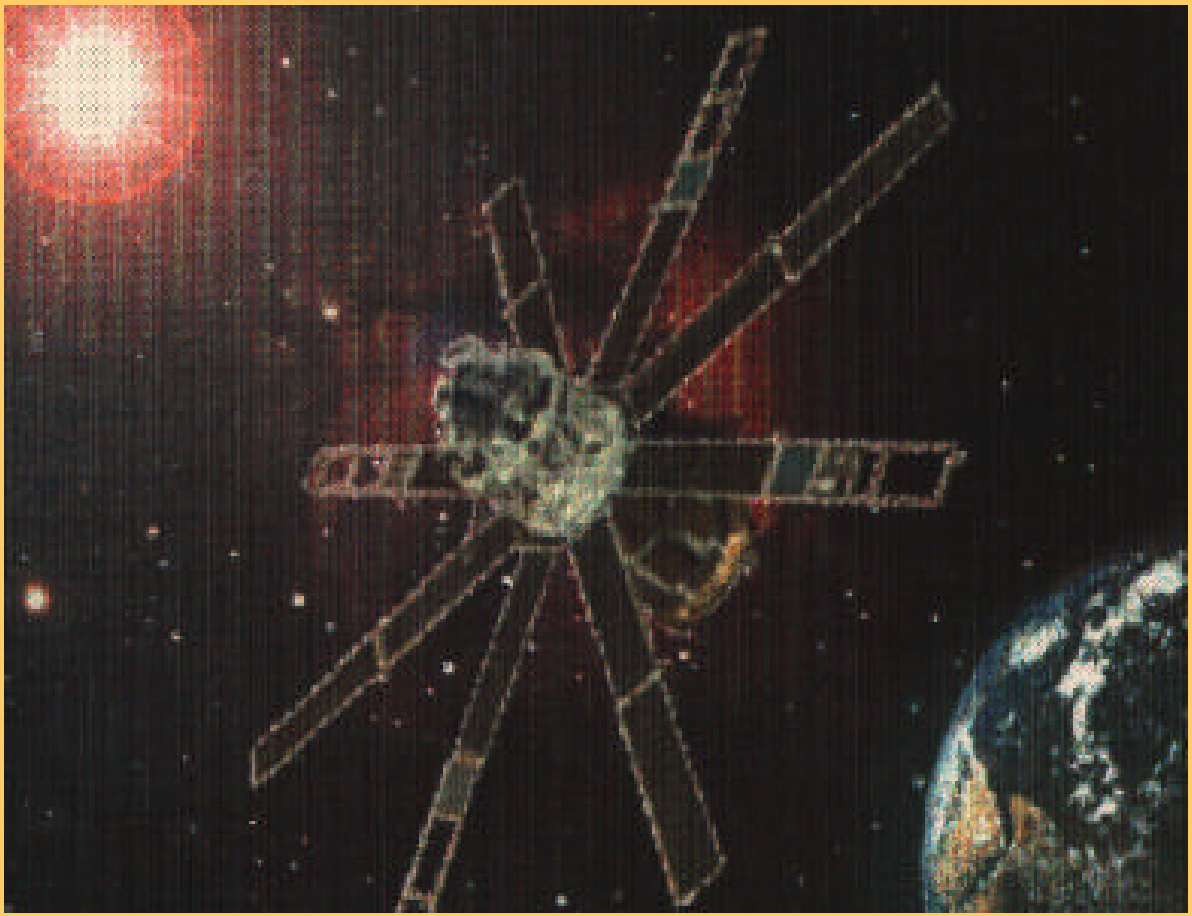
Complex
ORbital
Near-Earth
Observations of the
Solar
Activity

CORONAS-F

Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation (IZMIRAN)

Date of the launch 31 July 2001

Spacecraft mass	**2260 kg**
Payload	**395 kg**
Orbit	**548/500 km**
Orbital period	**95 min**
Inclination	**82.5°**



CORONAS-F SCIENTIFIC OBJECTIVES

The seismologic study of the solar interior based on observed global oscillations;

The study of energy transport from the solar interior to the surface, its build-up in the upper atmosphere and subsequent release in non-stationary solar events;

The study of major dynamic phenomena of the active Sun (sunspots, flares, plasma ejections);

The study of cosmic rays, accelerated in solar flares, as well as of other active phenomena, their escape, interplanetary propagation, and geophysical effect.

CORONAS-PHOTON

- mission under development

CORONAS-PHOTON

CORONAS-PHOTON mission is the third satellite of the Russian CORONAS program on the Solar activity observations. The main goal of the mission is the study of the Solar flare hard electromagnetic radiation in the wide energy range from Extreme UV up to high energy gamma - radiation (~2000MeV).

Principal Organization: Moscow Engineering Physics Institute

Principle Investigator: Dr. Yu.D. Kotov
Tel/fax (007-095)-3240616
E-mail: kotov@mephi.ru

Main objectives of the CORONAS-PHOTON mission:

- study of the dynamics of the energy spectra of hard electromagnetic radiation from EUV to 2000MeV;
- nuclear gamma-lines spectroscopy of Solar activity regions;
- detection of solar neutrons with energies higher 5MeV;
- measurements of polarization and rapid variability of hard X-ray emission during the flares;
- monitoring of the Solar extreme ultra-violet (EUV), soft and hard X-ray emissions;
- detection of the fluxes of electrons, protons and nuclei at the satellite orbit;
- monitoring of Earth upper atmosphere by occultation measurements of EUV and soft X-rays radiated by the quiet Sun.

CORONAS-PHOTON mission summary

1. Payload

Instrument	Measured radiation	Organizations	Weight kg
Instruments for electromagnetic radiation and neutrons			
High energy radiation spectrometer NATALYA-2M	Gamma-rays spectroscopy 0.3 – 2000MeV; Neutrons 20 – 300MeV	Moscow Engineering-Physics Institute (MEPhI);	36.0
Low energy gamma-ray spectrometer RT - 2	Hard X-ray spectroscopy: Phoswich mode: 15 – 150keV; Spectrometric mode: 100 – 2000keV (Si and CZT - detectors are under study)	TATA Institute of Fundamental Research (TIFR), Bombay	68.0
Hard X-ray polarimeter PENGUIN	Soft X-ray radiation 1 – 10keV Hard-X-ray polarization 20 – 150keV; X-ray & gamma-ray spectroscopy 0.15 – 5MeV;	Ioffe Physical-Technical Institute, St-Petersburg; MEPhI	29.5
Fast X-ray monitor FXM	Hard X-ray with sub-msec temporal resolution 20 – 500keV	MEPhI	10.5

Instrument	Measured radiation	Organizations	Weight kg
Solar flare and cosmic gamma-burst spectrometer Konus-RF	Hard X-ray & gamma-ray spectroscopy with high temporal resolution 0.10 – 12MeV	Ioffe Physical-Technical Institute, St-Petersburg	31.5
Telescope-spectrometer for solar x-ray TESIS	Full disk imaging: Bands: 171-182Å: ?/d?=20, d?=2’’ 290-320Å: ?/d?=20, d?=2’’ Field of view: Solar disk 45’’ Corona 2 – 5 R_{Sun} Band 8.418-8.423Å: two channels with orthogonal polarization ?/d?=10^3, d?=4’’	Lebedev Physical Institute (FI RAN) Moscow;	67,5
Multi-channel Extreme ultra-violet and Soft X-ray monitor EUV-PHOKA	Timing of the full disk radiation in the next spectral windows: λ < 10nm, λ = 17 – 25nm, λ = 30 – 35nm (HeII), λ = 50 – 65nm (HeI), λ = 70 – 90nm (OII – OIV) λ = 121.6nm (Lyman-α), visual band	MEPhI; Astrophysical Institute, Potsdam; Fraungofer Institute IpM, Freiburg	10.0

Instruments for charge particle measurements			
Energetic particle analyzer ELECTRON-5-PESKA	e : 0.2 – 2MeV p : 1.0 – 150MeV a : 1.5 – 50MeV/nucleon Nuclei (Z <26) 2.0 – 50MeV/nucleon	Institute of nuclear physics of Moscow State University; University de Alkala, Madrid	16.0
Energetic particle telescope STEP-F	e : 0.15 – 10MeV p : 4.0 – 62MeV a : 15.5 – 245.5MeV	Kharkov State University	7.5

2. Spacecraft

Orientation of longitudinal axis to the Sun direction (at the day part of orbit) Destabilization of the longitudinal axis from the Sun direction during the shadow part of the orbit	Absolute pointing accuracy ±10' < 0.3'/sec	Posteriori pointing accuracy ≤1.5'
Electric power (total)	775 Watts	
Nominal mission lifetime	3 years	Extended 5 years


Orbit:
Circular 500±10 km
Inclination 82.5^0
Launch 2006
by Cyclone-3M

- **INTERHELIOPROBE –**

  mission under investigation

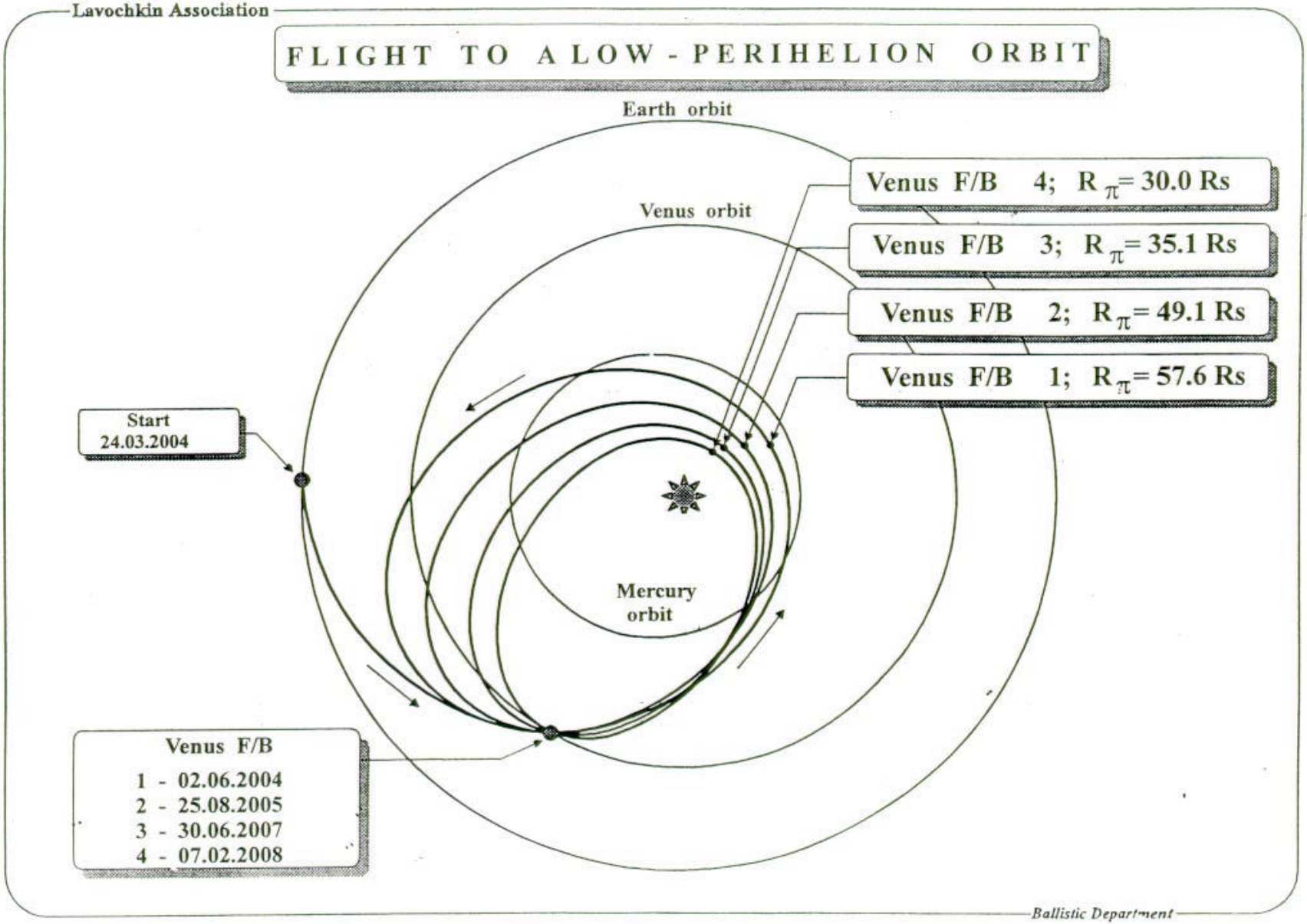
INTERHELIOPROBE

MAIN SCIENTIFIC GOALS

- **to investigate mechanisms of the coronal heating and solar wind**
- **to investigate the fine structure and dynamics of the solar atmosphere in the polar and equatorial regions**
- **to determine the origin of the most powerful solar activity phenomena (solar flares and CMEs)**
- **to investigate generation and propagation of solar energetic particles**

Leading organisations: **IZMIRAN, IKI and NPO Lavochkin**

INTERHELIOPROBE



INTERHELIOPROBE

SOLAR INSTRUMENTATION

- Optical telescope
- Magnetograph
- X-ray imager-spectrometer
- Coronagraph

HELIOSPHERIC INSTRUMENTATION

- Solar wind ion and electron analyzer
- Solar wind plasma and dust analyzer
- Magnetic wave complex
- Magnetometer
- Energetic particle telescope
- Neutron detector
- Radio spectrometer
- Electron gun

INTERHELIOPROBE

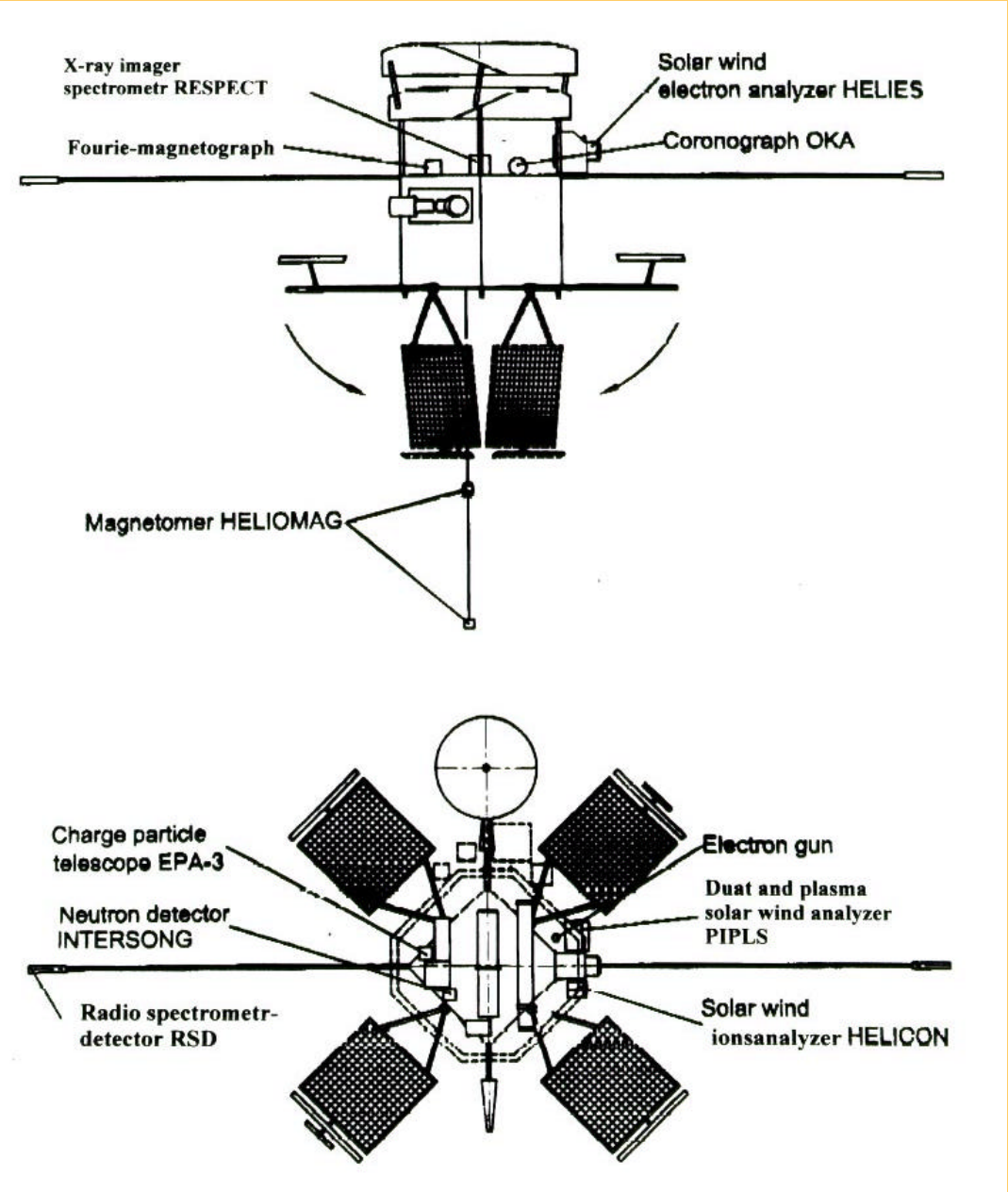
Spacecraft:

- Payload mass - 50-60 kg
- Power - 100 W
- Telemetry - 60 kb/s
- Solar arrays - 4 sq.m.

- 3-axis - Sun pointing attitude
- stability -3''/15 min

Electric low-thrust propulsion
Launcher Soyuz-2

Launch year 2007-2008



- **RESONANCE -**

mission under investigation

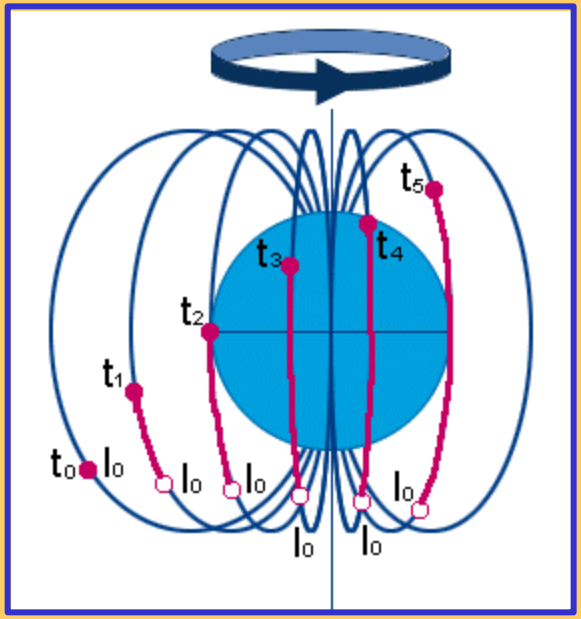
RESONANCE project

Investigation of wave-particle interactions and plasma dynamics in the inner magnetosphere.

Leading scientific organizations:
Space Research Institute (IKI), Moscow
Institute of Applied Physics (IPF) N.Novgorod

Scientists from Russia, France, Finland, Germany, USA and Ukraine take part in the project.

RESONANCE project



Magnetosynhronous orbit

RESONANCE satellite motion along the selected magnetic flux tube, mapping to the heating station.

Estimated conjunction duration is up to 3 hours for passive experiments

Orbit:
Apogee: ~30 000 km,
Perigee: ~ 1 800 km,
Inclination: + and - 63.4^{o} (two S/C)

RESONANCE project

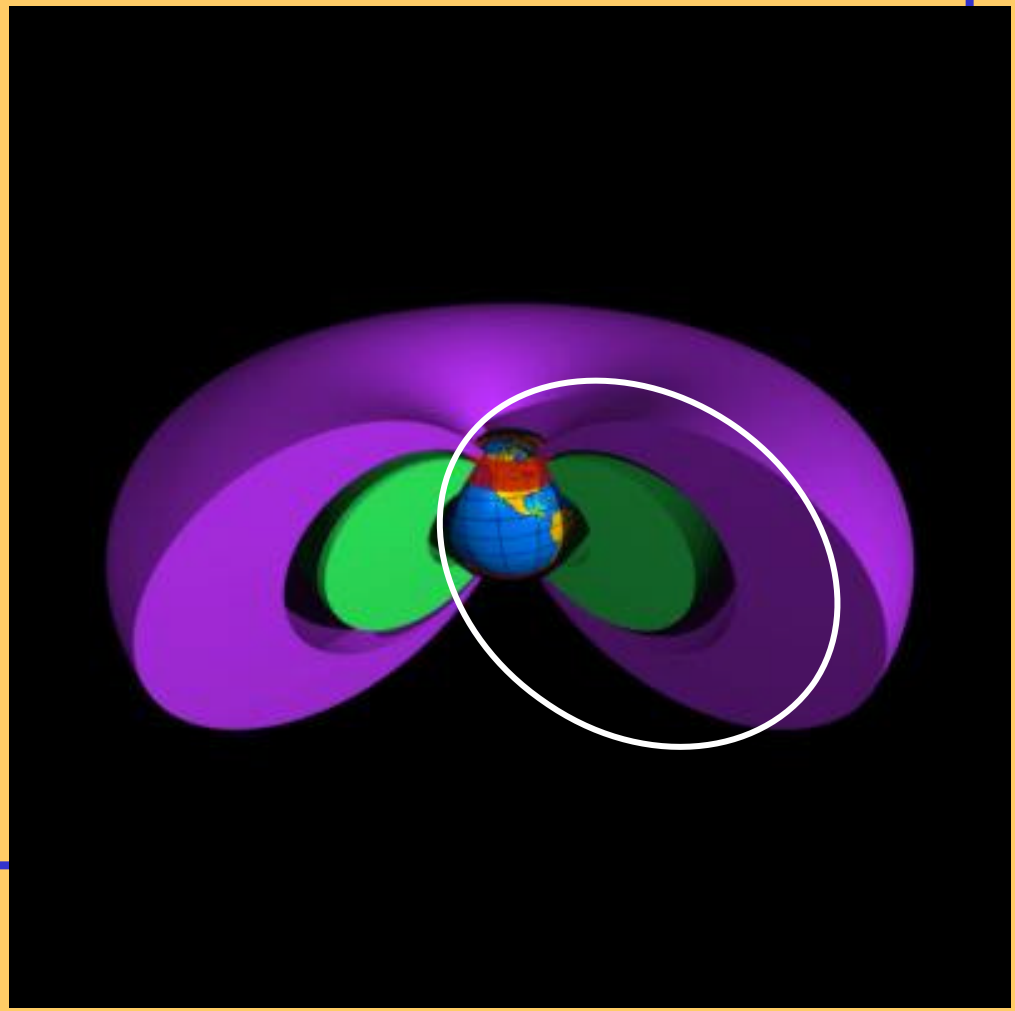
Project RESONANCE main goals:

- **Magnetospheric science and space weather-related investigations:**

  - ***Ring current and outer radiation belt***
  - ***Plasmasphere***
  - ***Magnetospheric cyclotron maser***
  - ***Mid-altitude auroral zone and polar cap***

RESONANCE Outer Radiation Belt & Geostorms

- Injection development studies
- MeV electron dynamics
- Ring current formation
- Magnetic field reconfiguration



RESONANCE

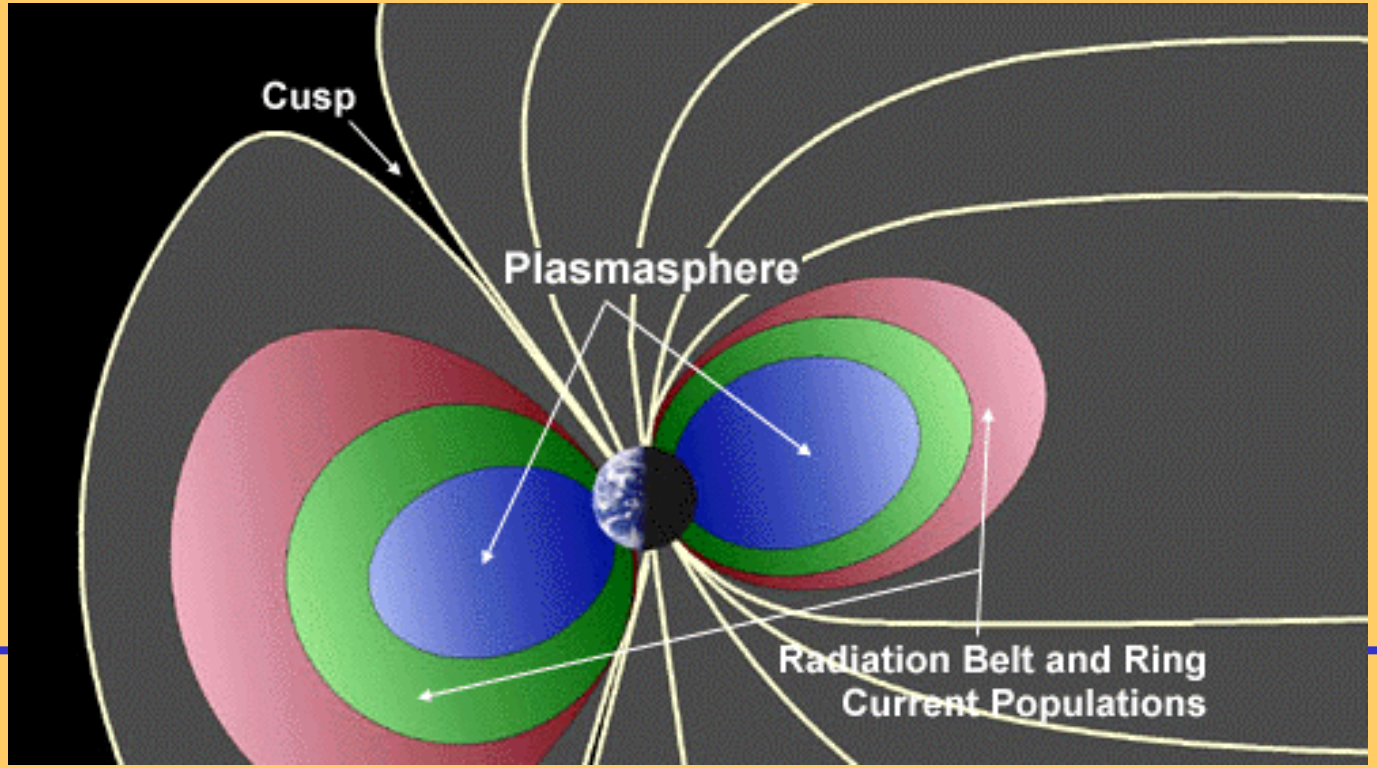
Plasmasphere studies

Plasmapause storm-time dynamics

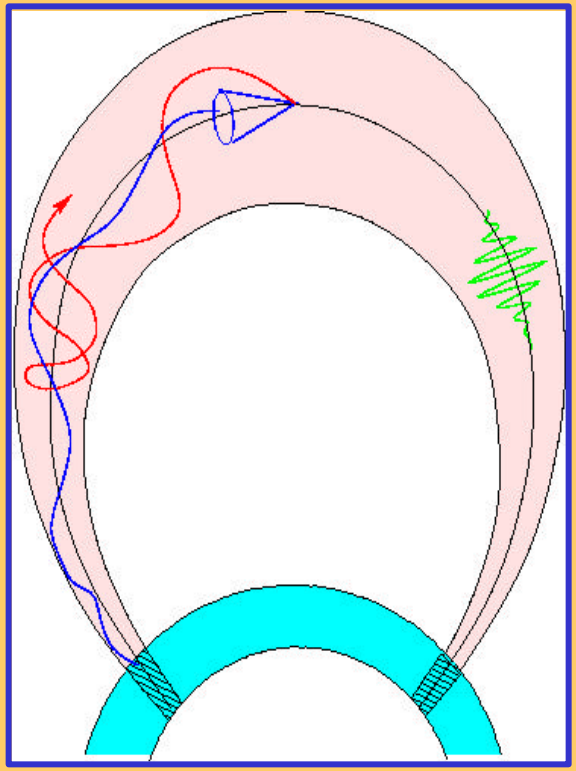
Plasmasphere refilling

Flux tube content monitoring

Sub-auroral zone physics



RESONANCE Magnetospheric Maser



Precipitating particles (q ***<*** q ***c)***

Trapped particles (q ***>*** q ***c)***

$$w - w_H = k_{\|} v_{\|}$$

$$\left(w < w_H\right)$$

Active material:

Energetic electrons *(W > 5 keV)*
protons *(W > 10 keV)*

Electrodynamics system:

Magnetic flux tube with cold plasma;
Mirrors – conjugate ionosphere

Working modes:

Whistlers and ion-cyclotron waves

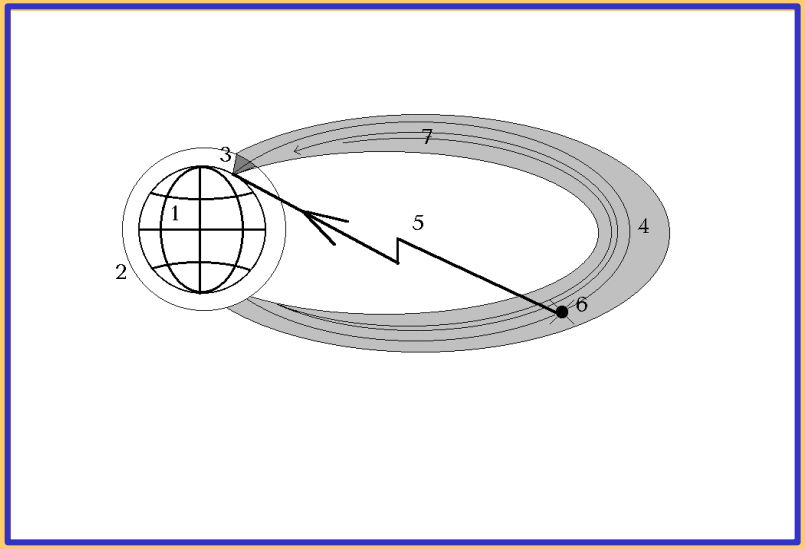
RESONANCE project

- **An artificial influence on the operation of magnetospheric maser.**

- ***Artificial excitation and/or stimulation of wave modes;***
- ***Modification of the flux of precipitating particles;***
- ***Modification of reflection index at the ionospheric footprint of the selected magnetic flux tube.***

RESONANCE project

Scheme of the joint experiment with a ground based heating facility (one satellite option).



Controlled positive or negative feedback will be added to the natural magnetospheric oscillator by means of real-time communication with the heating station

RESONANCE project

Scientific experiments (waves)

Magnetometer: *3 components of magnetic field in the frequency range DC – 10 Hz, dynamic range: 1 – 10 000 nT.*

DC and ULF electric field: *3 components of electric field in the frequency range DC – 35 Hz, dynamic range: DC – 120 dB, ULF – 80 dB.*

ELF/VLF electromagnetic field: *3 electric and 3 magnetic components in the frequency range 0.01 – 30 kHz, dynamic range: 70 (80) dB.*

HF electromagnetic field: *3 electric and 3 magnetic components in the frequency range 0.01 – 30 MHz, dynamic range: 70 (80) dB.*

RESONANCE project

Scientific experiments (plasma and particles)

Mutual Impedance Probe: *Plasma density and temperature measurements.*

Thermal plasma: *Electrons and 3 sorts of ions, range: 0.1-10^3 part./cm^3, time resolution: 1-5 sec.*

Hot plasma : *Electrons and 3 sorts of ions, energy range: 10-10^4 eV, dynamic range: 10–10^9, time resolution: ~ 1sec.*

Hot plasma: *Electrons, energy ranges: 5-50 keV, energy resolution: 100eV, time resolution: 10 ms.*

- **INTERBALL-PROGNOZ**

  – project under discussion

INTERBALL-PROGNOZ

Fast-track space weather & solar-terrestrial research mission by

- **Russian Space Research Institute (IKI) and NPO Lavochkin**
- **Ukrainian Space Research Institute and GKB Yuzhnoe**

- **Tests of space weather-related methods and instrumentation**

- **Monitoring and investigations of solar input, outer magnetosphere, ionosphere and magnetosphere-ionosphere interaction**

http://www.iki.rssi.ru/interballp

INTERBALL-PROGNOZ

Joint Russian-Ukranian project:

Russian part — **High-apogee S/C «Interball-3»**
launch 2005 in case of approval

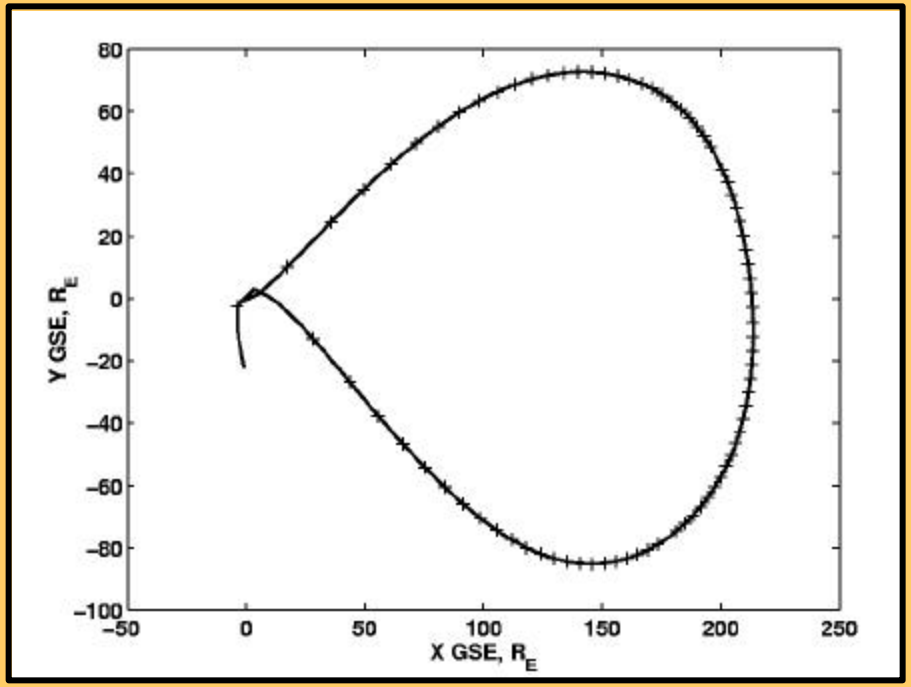
with magnetic field, solar radiation, solar wind, plasma and energetic particle measurements

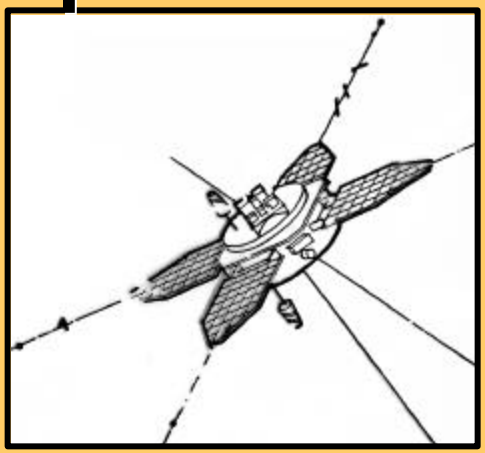
Ukrainian part — **Ionospheric S/C & Tracking station**

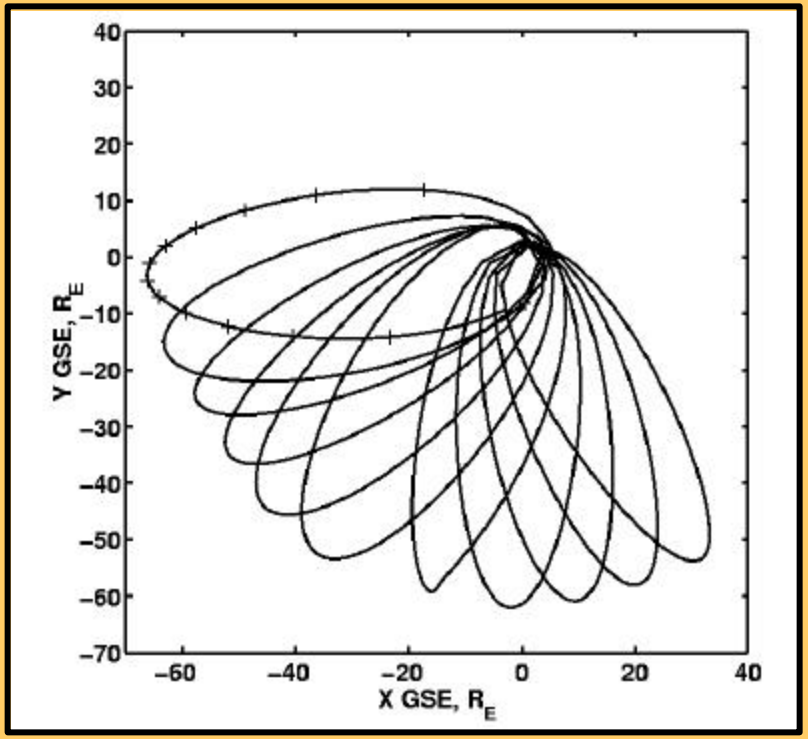
with ionospheric thermal plasma and precipitation, radio sounding, driftmeter measurements

Collaboration with international space weather program & self-sufficiency of the project

High-apogee S/C on a Prognoz-? platform



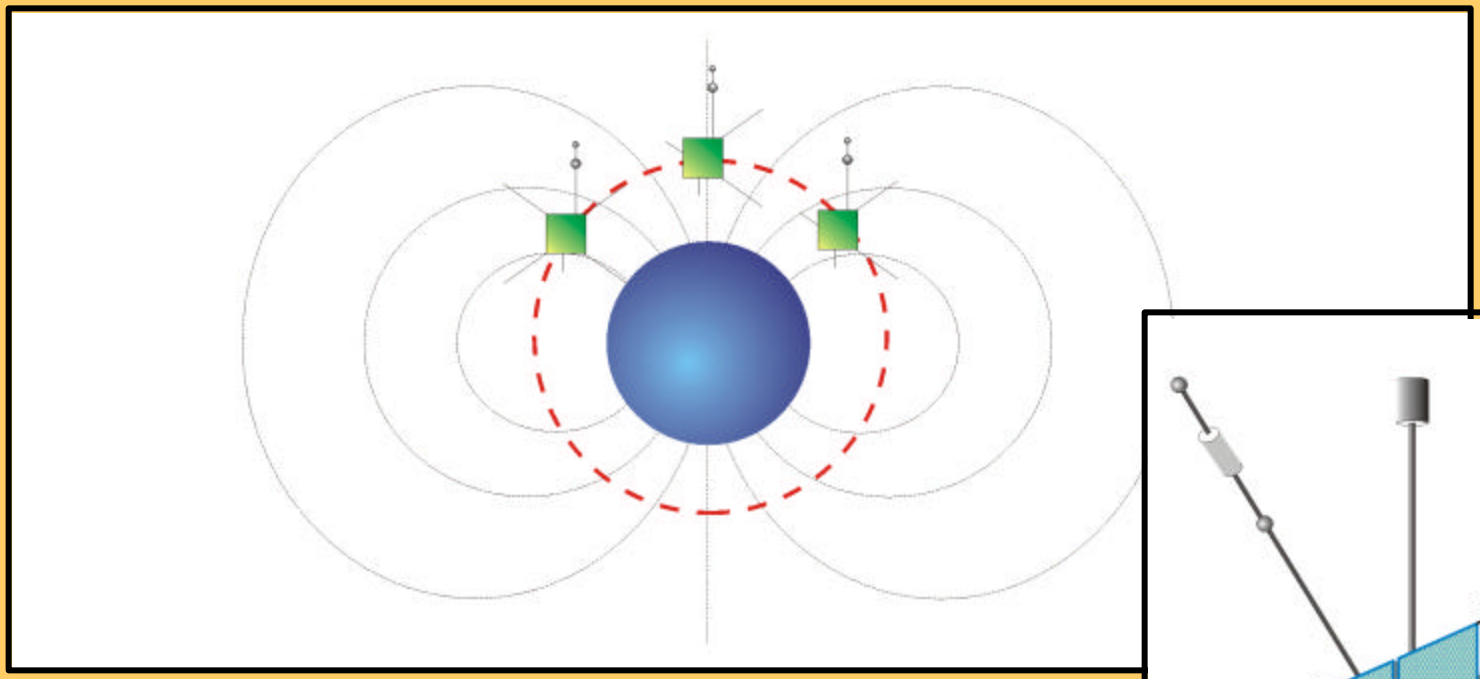


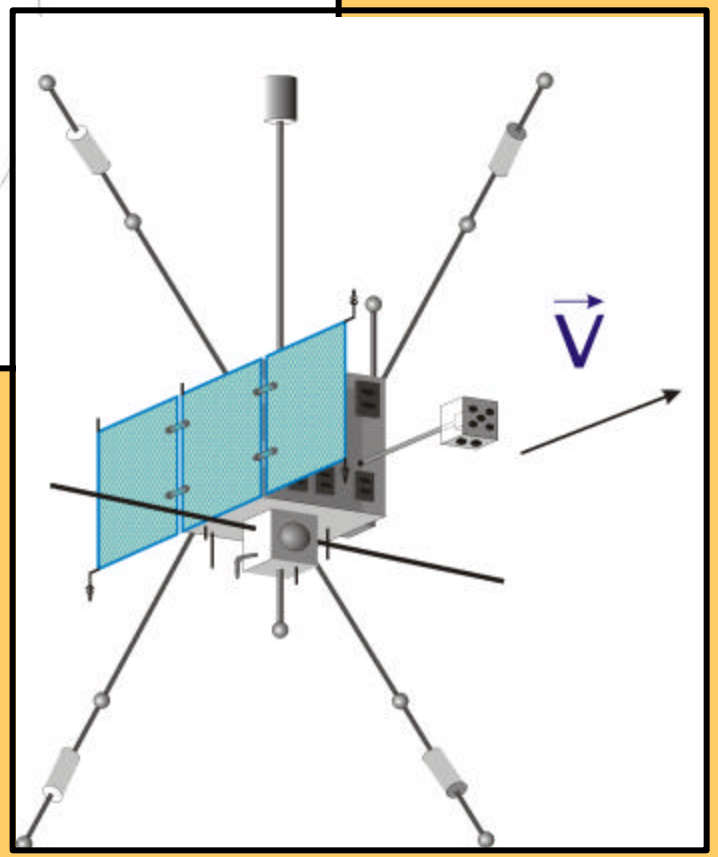


<u>1st stage</u> (6 months):
L1 monitor prototype and system tests

<u>2nd stage</u> (3-4 years):
outer magnetosphere research
elliptic orbit with apogee ~60 Re

Low apogee S/C on a micro-sat platform





3 micro-satellites (50 kg payload)

sun-synchronous dawn-dusk

circular orbit 600-700 km

- **ROY - project under discussion**

ROY/SCHWARM
(Joint RASA and DLR project)

Scientific Program and Tasks

Fundamental plasma phenomena studies

explosive **transformation of magnetic energy into plasma** thermal and kinetic **energies**

in-situ multi-point measurements

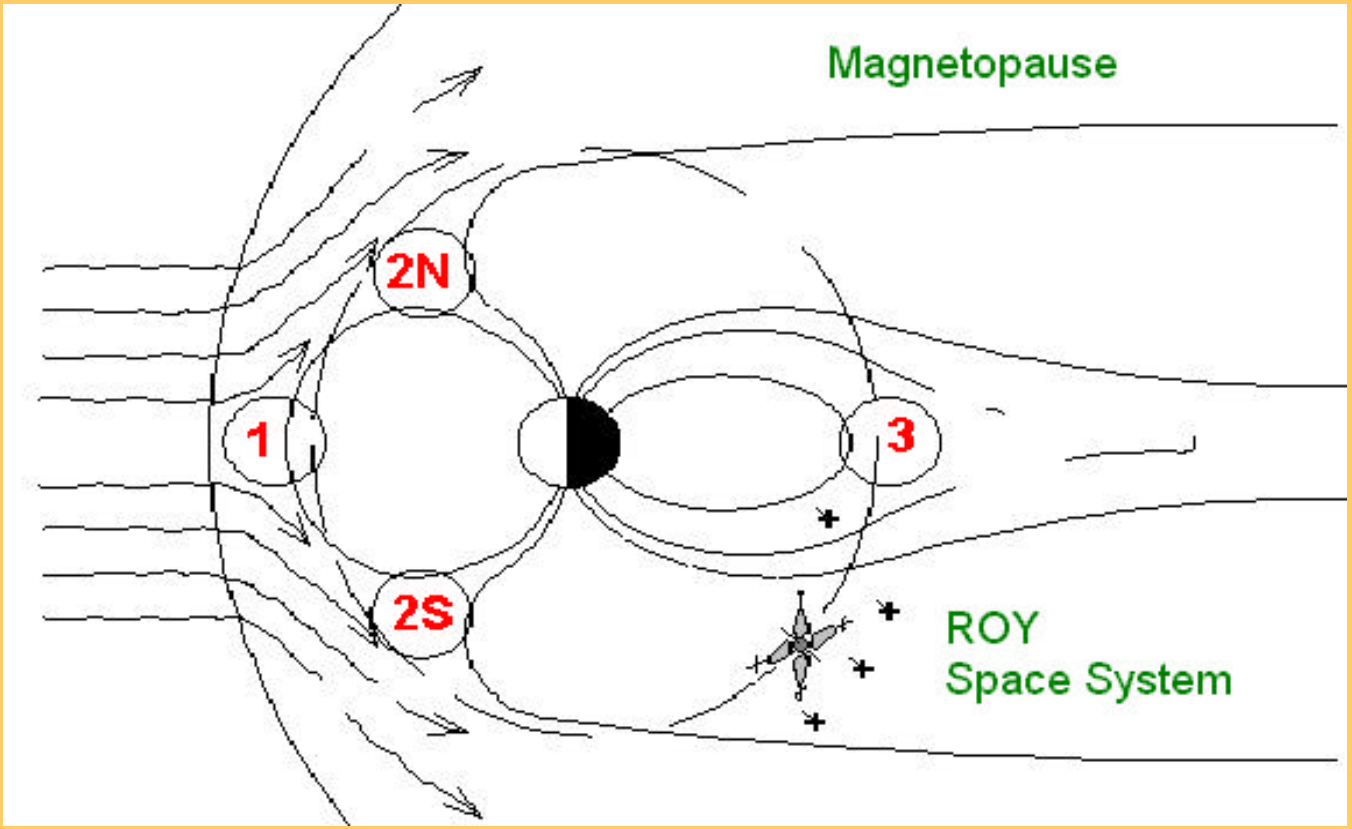
magnetospheric plasma **boundaries dynamics**
mass and energy transport through the magnetopause
substorm generation
strong **plasma turbulence**
magnetic field **annihilation**

remote scanning by radio-tomography natural at space scales (~ 10 - 300 km)

of **multi-scale** structures in **critical regions** of magnetosphere

http://bird.iki.rssi.ru/ROY/

ROY/SCHWARM



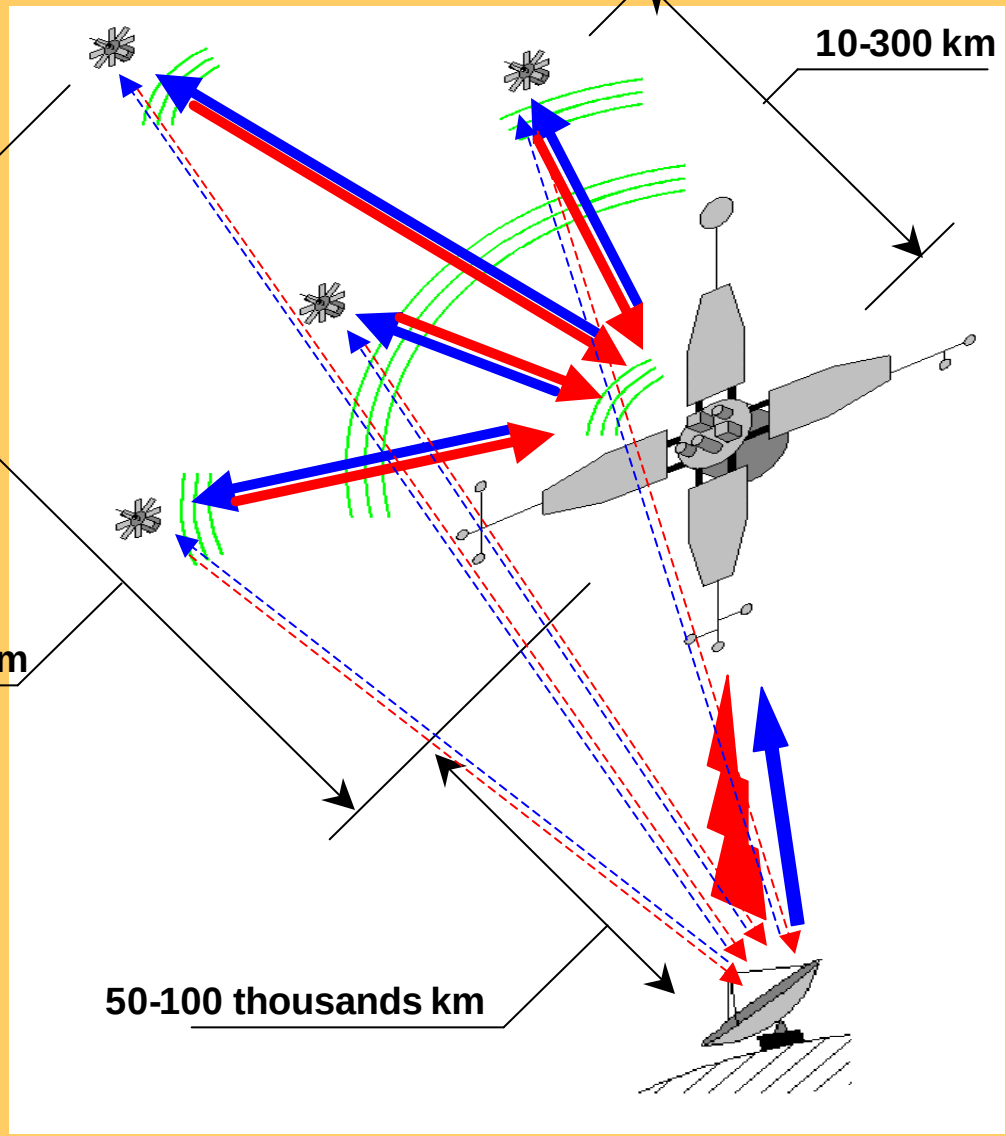
Key regions of magnetic field «reconnection» (annihilation) in magnetosphere:

1 – Sub-Solar Magnetopause
2 – Southern and Northern Cusps
3 – Substorm generation region

Apogee 75 000 - 100 000 km
Perigee 10 000 - 12 000 km
Inclination 62.8°

ROY/SCHWARM

SPATIAL CONFIGURATION AND RADIOLINKS IN THE “ROY” PROJECT



TOMOGRAPHY	150+1 kHz
COMMAND	5-10 Kb/s
TELEMETRY	1 Mb/s
HIGH BITRATE TELEMETRY	2-8 Mb/s
SPARE (command)	5-10 Kb/s
SPARE (telemetry)	256 Kb/s

- **Real-time data and forecast**

Space weather real-time data

Is important for research, monitoring and forecast

Input:

- **Solar images**
- **Solar wind & particles measurements**
- **Geo-radiation monitoring**
- **Ionospheric monitoring**
- **Geomagnetic data**

Output:

- **Real-time data transfer**
- **Algorithms of forecast**
- **Data dissemination**

Survey of russian space weather related sources

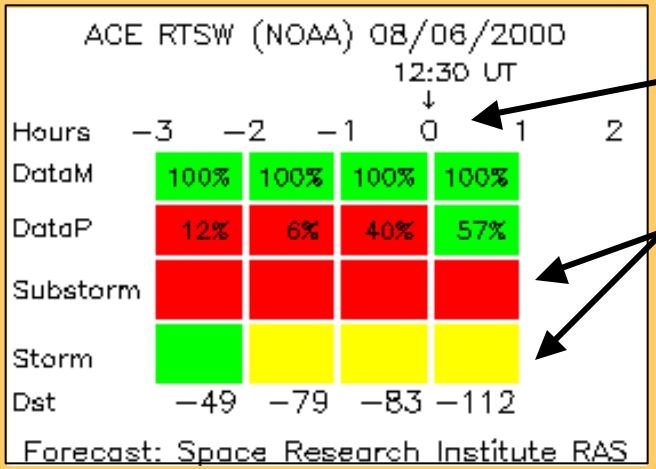
http://alpha.npi.msu.su/RSWI/rswi.html

Space weather forecast using real-time solar wind

http://www.iki.rssi.ru/forecast

Data source: NOAA/SEC ACE RTSW

Goal: reliable automated translation of solar wind data into geomagnetic forecast



Data availability for IMF and Solar Wind
- high
- low

Estimated Dst

Expected forecast time relative to NOW

Polar (substorm) and global (storm) energetics as Akasofu Epsilon

$E \sim vB^2\sin^4(q/2)$ Joules

	Substorm (90')	Storm (180')
	$> 5*10^{15}$	$> 10^{17}$
	10^{15} -$5*10^{15}$	10^{16} -10^{17}
	10^{14} -10^{15}	$5*10^{15}$ -10^{16}
	$< 10^{14}$	$< 5*10^{15}$

Accuracy of the forecast is limited currently by the quality of the real-time IMF data.

Other real-time Russian Resources in INTERNET

IZMIRAN Moscow geomagnetic, Cosmic rays, Forecast

http://forecast.izmiran.rssi.ru

ISTP/Irkutsk Geomagnetic, Solar images, Ionosphere

http://www.iszf.irk.ru & http://magnit.istp.net.ru/ogmo/patron

G.A.ZHEREBTSOV

Basic Profiles of Russian Space weather network
Room 302bc Saturday, 11.25

AARI Arctic and Antarctic geomagnetic

http://www.aari.nw.ru/clgmi/geophys/index.htm

RosHydroMet Forecast

http://www.mecom.ru/roshydro/pub/servers/ipg_0303/ipg_home.htm

Other stations: IMAGE geomagnetic , Meridian 210